REMARKS

For the purpose of clarification, and to facilitate the further examination of this application, Applicants note that Claims 26 through 44, which have been added by the foregoing amendment correspond to Claims 1-19 previously contained in co-pending application Serial No. 10/551,538. These claims are supported in the specification of the present application at least at page 4, lines 20-23; page 7, lines 4-6 and page 9, lines 13 through 19. Accordingly, incorporation of these claims into the present application is believed to be proper. Moreover, because the former claims in Serial No. 10/551,538 have been rejected on grounds of obviousness-type double patenting over Claims 1-25 of the present application, restriction with regard to Claims 26 through 44 is not appropriate.

The present invention is directed to a method of thermal mechanical treatment of steel, and to a method for producing steel coil springs or stabilizers which utilizes a combination of heating and "skew rolling" to treat a starting material in the form of a steel rod in order to produce certain desirable structural characteristics (described further hereinbelow) in the finished rolled product. Rods produced by the method according to the invention are advantageous for use in structural members that are subject to torsion, such as in springs or stablizers.

"Skew rolling" is a term of art which refers to a rolling technique that utilizes variously shaped rollers, including disk-shaped and conical rollers, as

well as cylindrical rollers, whose rotational axes are aligned at an angle relative to the longitudinal axis of the workpiece. Attached is a copy of a publication by A. Herbert Fritz et al entitled *"Fertigungs Technik"* (Manufacturing Technology), together with a translation of the pertinent portions thereof at page 371, which describes various types of skew rolling. (It is noted in this regard that the phrase "skew rolling" is an English translation of the German word "Schrägwalzen", which appears in both the original German-language version of the present application, and in the *"Fertigungs Technik"* publication. It is translated in the attached translation as "cross rolling".) Because the concept of "skew rolling" is germane to both the formal and prior art grounds of rejection set forth in the Office Action, a brief summary of the invention and the significance of skew rolling is first provided herein.

The processing technique according to the present invention provides a single rolling step, which achieves two important goals. First, it reduces the thickness of the processed steel rod to a desired diameter, and second, it endows the processed steel rod with a desired structure which leads to a desired gradient in its mechanical properties over its cross section, which is particularly beneficial for the use of the resulting product in coil springs, as noted previously. That is, the treated rods have a strength profile in their cross section, which reaches its maximum values in the "marginal area" adjacent the periphery of the rod.

To this end, according to the invention, the starting material is first heated to a temperature that is above the recrystallization temperature of the starting material. Subsequently, the temperature is equalized over the length of the rod, whose temperature along its length is kept essentially constant up to the point where the rod enters the roll gap between the skew rollers. Due to the skewed alignment between the rolling axis of the skew rollers and the longitudinal axis along which the rod moves, the rollers impart a twisting to the material in the rods, which is especially pronounced in the marginal area of the rods. Thus, a transformation or deformation gradient is established within the interior cross section of the rods, so that their metallurgical structure (that is, the degree of recrystallization within the cross section of the rod) varies from the outside to the inside. Following the transformation or deformation process, the rods are, if necessary, again heated to a temperature above Ac3, and the static recrystallization is completed, which leads to the formation of fine-grained austenite in the marginal or peripheral areas of the cross section of the rod. Subsequent hardening and tempering provides the marginal zone with a martensite structure which is of great strength. (See, for example, the specification at page 4, lines 1-15.)

As noted in the specification at page 9, lines 3-6, the orientation of the skew rollers is such that the direction of twisting of the structure of the rod is in the range of 35° to 65° relative to the longitudinal axis of the rods, which corresponds to the main direction of stress in a component that is subject to

torsion, such as in a spring. If the ratio of the starting diameter to the finish diameter is chosen so that the average degree of stretching is 1.5, while the maximum deformation (ψ) is at least 0.3, the "desired transformation gradient" is established over the rods cross section, which is optimal for this purpose. (See, for example, specification page 8, line 15 through page 9, line 6.)

With the foregoing as background, Applicants now address the grounds of objection and rejection set forth in the Office Action.

In response to the objection of Claims 1 and 17 as set forth in item 1, Applicants have amended Claim 1 to change the phrase "about a Ac3" to "above Ac3" which is consistent with Claim 17, and is what was intended.

Claims 1, 7, 10, 12, 13, 16 and 25 have been rejected under 35 U.S.C. §112, second paragraph for failing to particularly point out and distinctly claim the invention, based on certain formal issues identified in items 2 and 3 on pages 3 and 4 of the Office Action. In response to these grounds of rejection, Applicants note that the term "marginal area" is defined in the specification at page 5, lines 21-22 and page 8, lines 20-21. It refers to the "marginal region between 0.65 and 1.0 of the diameter of the rods". Accordingly, this term should be given the same meaning in the claims, which are therefore believed to be clear and definite in this regard.

The phrase "desired transformation gradient" in Claim 1, lines 11-12, on the other hand, refers to the fact that the transformation or deformation of the steel rod is greater toward its surface (that is, in the marginal area), and therefore varies across the cross section of the rod. A desired transformation gradient is discussed in the specification at page 4, lines 16-26, and also at page 5, lines 19-24. A targeted setting of the rolling parameters, such as rotational speed and rate of feed, as well as the choice of rolling contours and the specific angular alignment, achieves properties within the rods that "provide optimum prerequisites for their use especially in the spring industry". The "desired transformation gradient" is thus simply that transformation gradient which provides the desired properties in the processed rods, and is determined by the manufacturer of the end product.

Finally, the term "critical degree of transformation" is a term of art which is understood by those skilled in the art to refer to that degree of transformation which is necessary in order for recyrstallization to take place. (See Specification, page 5, lines 25-26.) In order to start recrystallization it is necessary to have a sufficient amount of recrystallization-nuclei. Such recrystallization-nuclei are created by the transformation of the rod. The term "critical degree of transformation" is known to those skilled in the art, particularly, in the field of material sciences and heat treatment of metals.

With regard to the indicated lack of clarity of Claim 10 due to the lack of a definition for the Greek letter ψ , Applicants have amended the language of Claim 10 to refer to "the maximum degree of deformation ψ". See in this regard the specification at page 5, lines 17-19. The term "deformation (or transformation) degree" (German language "Umformgrad") is a term which is well known to those skilled in the art. Accordingly, Applicants respectfully submit that Claim 10 is now clear and definite.

Further, in Claim 7, the phrase "the roll gap" has been changed to "a roll gap of said rolls of the skew rolling stand". Moreover, Claim 7 now depends from Claim 16, which has been amended to recite that, "said skew rolling is performed in a skew rolling stand". Accordingly, the latter claims are now believed to be clear and definite as well.

Applicants note that new Claims 26-44, which have been incorporated from the related application Serial No. 10/551,538, have been revised in a manner consistent with Claims 1-25. Moreover, corresponding formal grounds of rejection were set forth in the Office Action mailed April 28, 2008 with regard to that application. The foregoing arguments, together with the indicated revisions, are believed to be responsive to all grounds of rejection which were articulated in that Office Action.

Claims 1-15, 17, 18, 21, 24 and 25 have been rejected under 35 U.S.C. §103(a) as unpatentable over Bilgen et al (German patent document DE 198 39

383, which corresponds to U.S. Patent No. 6,458,226) in view of Hathaway (U.S. Patent No. 2,261,878). In addition, Claim 16 has been rejected as unpatentable over Bilgen et al in view of Hathaway and further in view of Borowikow et al (German patent document DE 100 30 823). However, for the reasons set forth hereinafter, Applicants respectfully submit that all claims of record in this application distinguish over the cited references, whether considered separately or in combination.

The Office Action indicates at page 4 that Bilgen et al discloses a process for thermo mechanical treatment of steel which includes inductive heating of a starting material, such as spring steel, austenitizing the product, holding its temperature for a short time, forming the material into a formed product at a temperature above the recrystallization temperature and quenching to martensite and tempering. The Office Action acknowledges, however, that Bilgen et al does not provide further detail on the nature of the formation into a formed product. In particular, in Bilgen et al no skew rolling step is disclosed.

However, the latter feature of the invention is said to be provided by Hathaway in that the process carried out by the straightener 11 and feed rolls 12 and 13, together with winding or coiling 14, is equivalent to skew rolling and winding into a coil spring. Applicants respectfully submit, however, that "skew rolling" as discussed and defined above and in the specification of the present application differs substantially from the rolling process disclosed in Hathaway.

Specifically, the Hathaway process itself includes none of the characteristics of skew rolling as that term is understood by those skilled in the art (as discussed above), and does not produce the same effects in terms of "a predetermined twisting of the material in a marginal area and a desired transformation gradient...over a cross section of the rod" as recited, for example, in Claims 1 and 26.

In Hathaway, the spring wire is wound cold. The wire is unwound from the coil and is straightened in the cold condition before it is wound to form the spring. In the process defined in Claims 1 and 26, skew rolling is carried out on a heated round rod. Hathaway contains no discussion of skewing the roller axes relative to the longitudinal axis of the rolled rod.

The use of the skew rolling technique is the process according to the present invention permits a reduction of the diameter of the round wire in a single pass. Moreover, as a result of the process, a high roundness of the wire cross section is maintained, whereas, during rolling in two steps, the wire is first ovalized and then rolled cylindrical again, so that the cross section roughly equals a square with rounded corners.

Skew-rolling on the other hand, considerably contributes to the formation of structural characteristics which are adjusted by the technique according to the present invention. That is, when the deformation takes place by skew-rolling or cross-rolling (in which the axis of rotation of the rollers is skewed relative to the

longitudinal axis of the workpiece), a maximum deformation occurs in the marginal or edge areas (that is, the areas adjacent the outer periphery). Moreover, as noted in the specification at page 6, lines 14-17, the direction of twisting in the marginal region of the rods is at an angle between 35° and 65° relative to the longitudinal axis of the rod. As a result, the most favorable structural characteristics (fine-grained structure, structural strength) occur in the edge areas where, during later use, highest stress (tension) takes place in the case of coil springs. The same effects cannot be achieved by the conventional rolling technique disclosed in Hathaway.

Because of the fact that, during skew-rolling, deformation takes place along a diagonal with respect to the axis of a workpiece, the alignment of the structure also takes place diagonally with respect to the longitudinal axis of the workpiece. Correspondingly, the structure and strength related characteristics of the material are also improved in this direction. This feature of the invention is particularly important, because coil springs are generally stressed by torsion, with the main tensioning angle being situated approximately at an angle of 45° relative to the longitudinal axis of the wire or rods. The twisting direction of the structure generated by skew rolling is aligned corresponding to the main tensioning direction of the later stressing, which is especially beneficial in the case of springs. The conventional rolling technique in Hathaway also does not achieve this effect.

In light of the foregoing remarks, this application should be in consideration for allowance, and early passage of this case to issue is respectfully requested. If there are any questions regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #103020.59950US).

Respectfully submitted,

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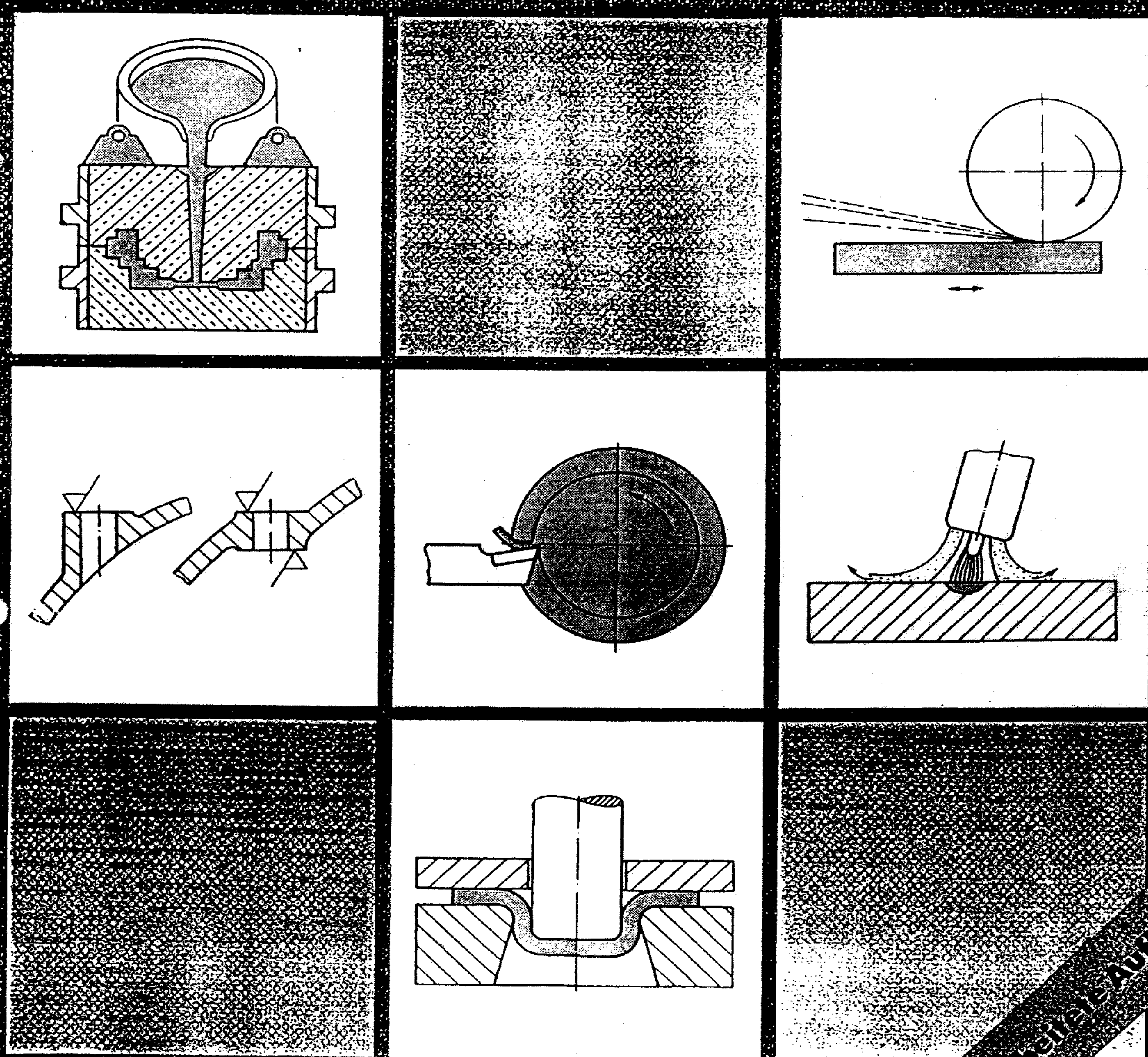
FRITZ/SCHULZE

FERTIGUNGS-TECHNIK



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verdeutlicht. Dabei liegt das Werkstück auf einem hartmetallbestückten Auflagelineal, das den Werkstückmittelpunkt um das Exzentrizitätsmaß *e* unterhalb der Walzenachsen fixiert. Die bewegliche Gewindewalze wird durch eine hydraulische Vorrichtung radial gegen das Werkstück und die ortsfeste Gewindewalze zugestellt. Dieses Verfahren ist bis zu einer Gewindelänge von etwa 120 mm geeignet.

Längere Gewinde müssen im *Axialverfahren* hergestellt werden. Hierbei wird das Werkstück gleichzeitig beim radialen Zustellen der Gewindewalzen axial vorgeschoben. Die Vorschubgeschwindigkeiten liegen zwischen 80 mm/min und 200 mm/min. Im Durchlaufverfahren sind nach diesem Walzprinzip Gewindestangen mit „endlosen" Gewinden herstellbar.

Beim Schrägwalzen sind die Walzenachsen entsprechend Bild 5-24 gekreuzt. Dadurch entsteht ein Längsvorschub in dem um seine Längsachse rotierenden Werkstück. Das Werkstück wird im Walzspalt durch Anlageleisten und eine Führungswalze (nicht im Bild gezeigt) gehalten. Die doppelkegeligen Arbeitswalzen sind unter einem Kreuzungswinkel von 3° bis 6° angeordnet, so daß das Werkstück schraubenförmig in Vorschubrichtung über die Stopfenstange bewegt wird. Infolge des Kegelwinkels verengt sich der Walzspalt; dies führt zu einer Stauchung des Werkstoffs mit seitlichem Ausweichen. Die radialen Zugspannungen verursachen im Zusammenwirken mit dem ständigen Wechsel der Beanspruchungsrichtung ein Aufreißen des Werkstücks im Kern. Der rotierende Stopfen glättet das Rohrinnere und bewirkt eine präzise Wanddickenauswalzung im Querwalzteil des Walzspalts.

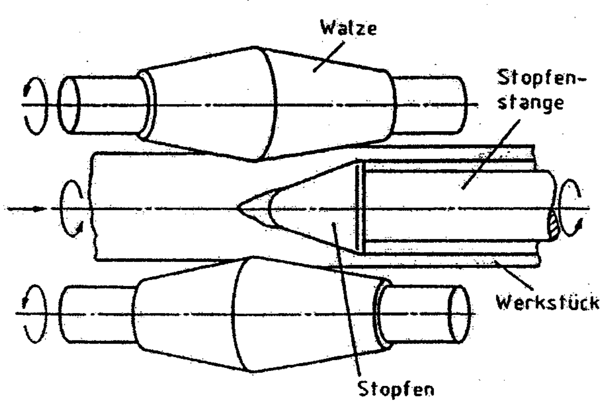

Bild 5-24. Schrägwalzen mit doppelkegeligen Walzen (Stopfenwalzwerk zur Rohrherstellung).

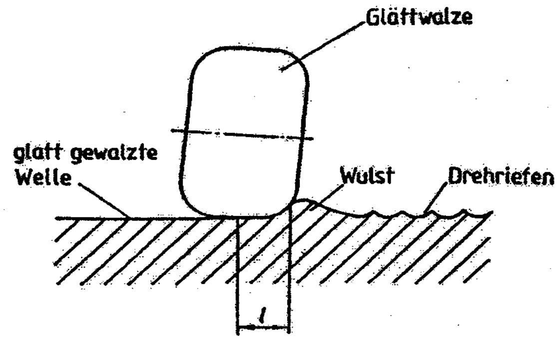

Bild 5-25. Schräggestellte Glättwalze zum Einebnen von Drehriefen; erreichbare Rauheit $R_z \approx 0{,}5$ µm.
l Länge der Eindruckmarke

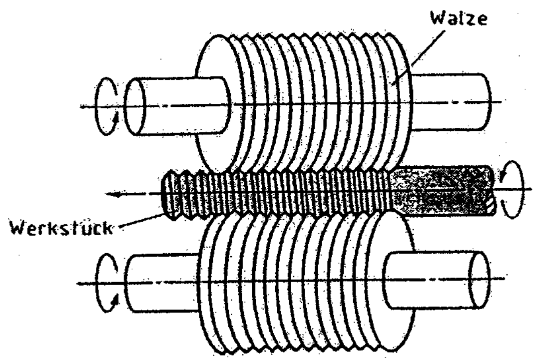

Bild 5-26. Schräggestellte Profilwalzen zur Gewindeherstellung (Durchlaufverfahren für Endlosgewinde).

Schrägwalzverfahren werden auch mit scheiben- und kegelförmigen Walzen bei der Rohrherstellung sowie mit zylinderförmigen Walzen beim *Glattwalzen* von Rohren und Stäben gemäß Bild 5-25 eingesetzt. Beim Gewindewalzen im Durchlaufverfahren können schräggestellte Profilwalzen mit in sich geschlossenen Gewindefurchen eingesetzt werden; dies verbilligt die Werkzeugherstellung. Bild 5-26 zeigt das Prinzip.

5.3.1.2 Verhältnisse im Walzspalt

Zur Konstruktion von Walzwerken und deren Antrieben ist es notwendig, die Walzkräfte, Walzmomente, den Arbeitsbedarf und die Walzleistungen vorauszuberechnen. Dazu müssen die Verhältnisse im Walzspalt betrachtet werden; dies geschieht am übersichtlichsten an Walzen für die Flachmaterialherstellung.

CIP-Kurztitelaufnahme der Deutschen Bibliothek

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English Translation of attachment (*Fertigungs-Technik*)

When **crossrolling**, the roller axes are crossed corresponding to Illustration 5-24. As a result, a longitudinal advance is created in the workpiece rotating about its longitudinal axis. The workpiece is held in the roller gap by means of contact strips and a guide roller (not shown in the illustration). The double-conical working rollers are arranged at an angle of crossing of 3° to 6°, so that the workpiece is moved helically in the advancing direction by way of the stopper rod. The roller gap narrows as a result of the conical angle; this leads to an upsetting of the material with lateral deflections. Interacting with the continuous change of the stressing direction, the radial tensile stress causes a ripping-open of the workpiece in the core. The rotating stopper smoothes the tube interior and causes a precise rolling-out of the wall thickness in the crossrolling portion of the roller gap.

Illustration 5-24. Crossrolling by Means of Double-Conical Rollers (Mannesmann-Type Rolling Train)

Walze	Roller
Stopfenstange	Stopper rod
Werkstück	Workpiece
Stopfen	Stopper

Illustration 5-25. Slanted Smoothing Roller for Flattening Tool Marks; Achievable Roughness $R_z \approx 0.5\ \mu m$. l Length of Impression Mark

Glättwalze	Smoothing roller
Glatt gewalzte Welle	Smooth-rolled shaft
Wulst	Bead
Drehriefen	Tool marks

Illustration 5-26. Slanted Profile Rollers for Producing Threads (Continuous Operation for Endless Threads)

Walze	Roller
Werkstück	Workpiece

Crossrolling methods are also used by means of disk-shaped or conical rollers during the production of tubes as well as by means of cylindrical rollers when *reeling* tubes and rods according to Illustration 5-25. In the case of thread rollers in the continuous operation, slanted profile rollers can be used which have inherently closed thread grooves. This reduces the costs of the tool production. Illustration 5-26 shows this principle.